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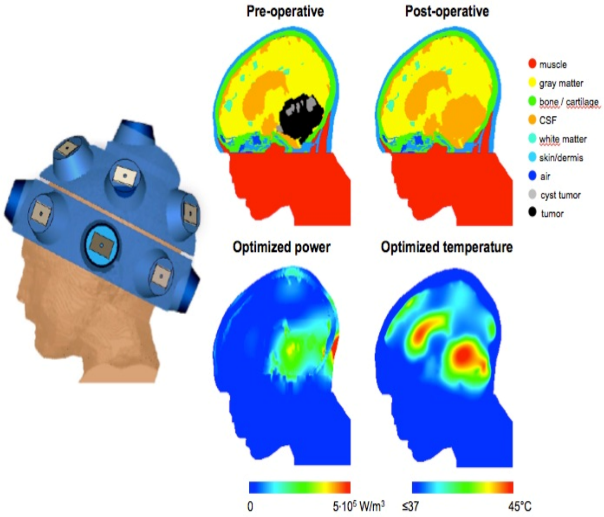
Purpose/Objective: Cancer is the most common cause of death at ages 1-16. Approximately 300 children annually develop a malignancy in Sweden and one third of these are brain tumors. Modern therapy cures 75% of all children struck with cancer. However, the tough therapy, including radiotherapy, has both acute and long-lasting, effects. Even low doses of ionizing radiation to the brain can cause intellectual impairment as well as perturbed growth and puberty.
Hyperthermia has gained a reputation of effective radio- and chemo-sensitizer, which has minimal side effects. Our hypothesis is that the focused microwave hyperthermia will allow a reduced radiation dose with maintained treatment outcome and no added toxicity. A novel antenna applicator for microwave hyperthermia allowing treatment of deep brain tumors has been designed. The goal of this study is to investigate the feasibility of focused heating deep inside the head.
Materials and Methods: The number and position of antennas was determined by using the homogeneous SAM (Specific Anthropomorphic Mannequin) head model. The focusing abilities of the resulting applicator were then investigated using a 13-year old patient model. Specific absorption rate (SAR) and temperature distributions were computed for five realistic tumors located at various sites. Both pre-operative and post-operative situations were considered.
Results: The applicator consists of 16 antennas placed around the head in a helmet-like set-up and operates at a frequency range of 430-900 MHz. The antennas are attached to a parametric water bolus and aligned with the head shape.
The results show considerable target coverage in terms of SAR in the target region with a remarkably low SAR in critical tissues in both pre- and postoperative cases. The postoperative situation showed more favorable heating of the target volume as exemplified by temperature distribution in meduloblastoma shown in Figure 1. The achieved median temperature was 42°C while for the preoperative cases, target temperatures were up to 3 degrees lower due to relatively high perfusion of the target.



Conclusions: The newly designed system is capable of selective intracranial heating in postoperative scenarios. For preoperative applications, further improvements in heating techniques are currently investigated.

EP-1272
Dose painting with Volumetric Modulated Arc Therapy (VMAT) can reduce kidney dose in abdominal neuroblastoma

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Purpose/Objective: For high risk abdominal neuroblastoma, traditional paediatric radiotherapy dogma dictates that an irradiated vertebral body (VB) should be fully included within the planning target volume (PTV) to ensure even dose distribution and avoid asymmetric growth. However, clinical experience indicates that beyond a threshold VB dose which abolishes or minimises growth, VB dose inhomogeneity is less relevant. Our objective was to assess whether dose painting using VMAT with a simultaneous integrated boost (SIB) can improve renal sparing.
Materials and Methods: Five cases of lateralised disease previously treated with fixed-fields were replanned with dual arc VMAT using conventional (VMAT-conv) and SIB (VMAT-SIB) techniques. PTV21 was the original, unadjusted PTV (clinical target volume +1cm). Adjacent VB were taken as those ≤1cm from PTV21. For VMAT-conv, 21 Gy in 14 fractions was prescribed to PTV21 and adjacent VB. For VMAT-SIB, 21 Gy was prescribed to PTV21, but adjacent VB were constrained to < 20% dose gradient, or >15 Gy minimum. Organ at risk (OAR) dose constraints were from the SIOPEN HR-NBL-1 protocol. Kidney doses were reduced iteratively to control

the shoulder, intermediate and high dose ranges of the dose volume histogram until coverage was tight but not compromised by ICRU 83. Homogeneity index was calculated as (D2%-D98%)/D50%. Two-sided paired sample t-tests were used to assess statistical significance, taken as *p*

Results: The mean volume prescribed 21 Gy was 398 cm^3 (range 259-611) for VMAT-conv and 318 cm^3 (range 213-526) for VMAT-SIB plans. By using VMAT-SIB, 72-78% of the volume of the VB at the level of the kidneys was prescribed 15 Gy rather than 21 Gy. PTV minimum, mean, maximum, D2% and D98% doses did not differ significantly between the plans. Both techniques achieved clinically acceptable plans. As expected, VMAT-SIB plans had greater VB dose inhomogeneity. VMAT-SIB allowed reductions in some combined (right plus left) and contralateral kidney doses (**Table 1**). Contralateral kidney V15, V18 and V21, combined kidney V12, V15 and V18, and ipsilateral kidney and liver doses were similar. The renal sparing achieved in at least 3 of 5 cases was judged to be clinically significant, most apparent at the 5 Gy level; contralateral kidney V5 was reduced from [24, 31, 95, 94, 81]% to [13, 6, 11, 20, 13]% in the 5 cases. An example is shown in **Figure 1**.

TABLE 1. Mean vertebral body and kidney doses.

	VMAT-conv	VMAT-SIB	
VERTEBRAL BODY			
Dmin to 1cc	20.4 Gy	15.7 Gy	p<0.001
D98%	20.5 Gy	15.9 Gy	p<0.001
D50%	21.1 Gy	18.8 Gy	p<0.001
D2%	21.5 Gy	21.2 Gy	p=0.015
Homogeneity index	0.046	0.300	p<0.001
CONTRALATERAL KIDNEY			
Dmax	19.2 Gy	14.5 Gy	p<0.001
Dmean	6.2 Gy	3.01 Gy	p=0.003
V2	99%	61%	p=0.004
V5	65%	12%	p=0.022
V12	5%	0%	p=0.002
COMBINED KIDNEYS			
Dmean	10.8 Gy	9.2 Gy	p=0.011
V5	75%	44%	p=0.022
V21	12%	9%	P=0.049

VMAT-conv, treating with conventional VMAT to PTV including vertebral body; VMAT-SIB, treating with VMAT to two dose levels using simultaneous integrated boost (SIB); Dmin 1cc, minimum dose to 1cc; D98%, the near-minimum dose, exceeded in 98% of the volume; D50%, median dose D2%, the near-maximum dose, exceeded in 2% of the volume; Dmax, maximum point dose; Dmean, mean dose; Vn, percentage of volume receiving at least n Gy.

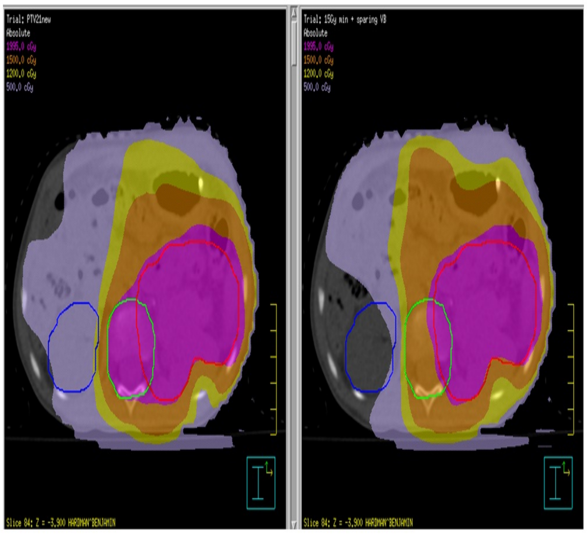

FIGURE 1. Representative axial images from VMAT-conv (left) and VMAT-SIB (right) plans. VMAT-SIB is able to spare the contralateral kidney (blue line) through controlled reduction in dose to the vertebral body (green line) whilst maintaining dose to PTV21 (red). Colourwash levels for 19.95 Gy, 15 Gy, 12 Gy and 5 Gy shown in purple, orange, yellow and lavender, respectively.

Conclusions: Dose painting with VMAT-SIB for high risk abdominal neuroblastoma is feasible. Controlled dose inhomogeneity in the VB can improve contralateral kidney sparing without increasing expected risks of asymmetric growth. The absolute differences between the techniques can be small and work is ongoing to identify factors that predict patients most likely to benefit. The benefit of sizeable reductions in the volume of contralateral kidney receiving 5 Gy is not well described, but may be clinically significant.

EP-1273

Optimization of cranio-spinal irradiation for paediatric medulloblastoma using VMAT and IMRT

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Purpose/Objective: To retrospectively compare VMAT and IMRT for cranio-spinal irradiation (CSI) of standard-risk medulloblastoma (MB) paediatric patients and to estimate their impact on the potential clinical benefit.

Materials and Methods: We selected 10 paediatric MB patients, with a median age of 7.5 years, who received CSI with a dose of 23.4 Gy, followed by a boost to posterior fossa up to 55.8 Gy, with 1.8 Gy/fraction.